3.4 Renewable Options for Power Generation

Scientists and experts in Armenia have studied and developed technologies to utilize renewable energy for many years, because of Soviet Union's predisposition toward building large fossil and nuclear power plants, renewable energy was considered as a novelty of interest only to scientists and academics. The government of Armenia has recently acknowledged the importance of the country's renewable energy resources and the need to develop these resources to help reduce the dependence on imported energy. The Least Cost Generation Development Plan for Armenia has included an investigation of these non-traditional, or renewable, energy sources for possible generation of electricity.

3.4.1 Wind Power

There has been much hope worldwide about wind energy as alternative energy source over the last decade in the world. Four countries--the United States, Germany, Denmark and India—made good progress in developing wind energy and operated 76 percent of the total world's wind generating capacity amounting to 7,202 MW in 1997. However, hopes about the wind-based energy as a viable alternative source of energy did not materialize. Even though technology has become cheaper lately in terms of $/kW, it is still expensive. For example, U.S. producers, under new contracts, receive around 3 to 4 cents per kWh. Wind producers in Germany, Denmark, and India are guaranteed 10.5 cents per kW, 9 cents per kW, and 6.4 cents per kWh, respectively [2].

International experience proves that wind-based electricity is not yet generally competitive *per se* with traditional sources of electricity such as fossil fuels. Thus, it is dependent on subsidies. Given the current state of Armenian financial resources to subsidize the implementation of wind energy, it is not anticipated that any significant progress will be made in the foreseeable future in this field.

A few wind pilot projects are currently under way in Armenia. Several discussions took place with ArmNedWind project management, a pilot project funded by Government of Netherlands that is at the stage of small wind turbine implementation at several sites. According to specialists, much more research work is required to complete wind mapping. Progress has been made in public awareness and participation related to wind power. The 3E Round Table was formed in Armenia for this purpose. According to expert assessment in wind energy, short-term large-scale implementation is unlikely to take place.

Despite these circumstances mentioned above, in the long term wind-based energy in Armenia appears to have modest potential. Various expert assessments estimated a cost of wind-energy ranging from 5 to 10.5 cents/KWh depending on wind velocity on site and reduced capital cost if wind turbines can be produced locally in Armenia.

The estimated total wind potential amounts to about 25-30 MW. For the purpose of this study, it

is assumed that this power can be available by 2020 and will be financed through private developments in rural areas (i.e. not sold to the national grid).

3.4.2 Solar Power

Similar to wind energy, the modern solar industry began in early 70s, when the well-known energy crisis erupted in the world. High capital cost for construction of photovoltaic (PV) cells have required subsidies from governments through the history of solar energy development. For example, in the U.S. such subsidization has taken the form of tax credits [2].

Although the natural potential of solar energy is fairly high in Armenia, the present cost of solar energy is higher than that of wind energy, discussed in the previous section. Given the fact that production of solar energy cannot be commercially justified in Armenia and needs to be subsidized, Armenia cannot afford this type of energy source at present. Therefore, it cannot be recommended as commercially feasible power alternative in Armenia now nor in the foreseeable future. Accordingly, no solar project was included in the list of recommendations.

At the same time, solar potential for rural areas should not be underestimated. Solar collectors installed at farms and rural houses may be a good supplemental source for space heating and hot water. Solar projects are not included in this study and are assumed to be privately implemented for distant rural areas on the relatively small scale.

3.4.3 Geothermal Power

The possibility of using geothermal energy has been thoroughly researched in Armenia. Before the break-up of the Soviet Union, local specialists paid serious attention to investigation of the feasibility of geothermal options. The studies carried out by Soviet specialists were supplemented later by a number of projects conducted by foreign companies, namely: a study by Lahmeyer International in 1994 and 1996, a project funded by the World Bank and performed by Petroleum Geology Investigators in 1998, two studies, one of which was conducted by GeothermEx under the USAID Energy Efficiency and Market Reform project (contracted by Burns and Roe in 1998), and the other one was done by Hagler Bailly in 1999.

The areas of known geothermal resources include Jermuk, Ankavan, Vorotan river valley, Martuni, Arzakan and Gyumri. All of the geothermal resources identified in Armenia can be classified as low-temperature resources (less than 100 $^{\circ}$C).

Both in 1994 and 1996 studies, Lahmeyer International recommended to include 5 to 55 MW of geothermal capacity in Armenia capacity mix within 5 year period. However, detailed investigation of GeothermEx under USAID project in 1998 proved this to be unrealistic. For economic electric power generation by binary cycle units, substantial production of thermal fluid at a minimum temperature of 100 - 150^{0}C would be required [4]. Thus, it is not expected that geothermal energy

will be a feasible source for *power* generation in Armenia, unless thermal waters of higher temperatures are discovered in the future.

However, GeothermEx study proved that the identified thermal water resource in Armenia, though they are generally of quite low temperature, may be commercially useable in a variety of direct-use applications. The likely uses of the Armenian resources include, primarily:

- Agricultural applications, such as greenhouse heating, soil warming, fish farming, etc.;
- Space heating and hot water supply, for individual buildings or in district heating systems;
- Tourism**,** using thermal water primarily for bathing for recreational or therapeutic purposes.

Taking into account all the considerations above, geothermal energy for power generation was not considered as bulk supply option in the current Least Cost Generation Plan.

3.4.4 Hydro Power

Hydropower can be considered the only commercially feasible and truly environmentally sound renewable energy source. Hydropower topics are discussed in detail in Section 3.2 of Chapter 3.

3.4.5 Biomass and Solid Waste

A brief investigation of municipal solid waste and industrial non-toxic waste was conducted. Several meetings took place at the Ministry of Ecology with management responsible for waste projects. In summary, the waste resources that can be utilized for biomass and/or municipal solid waste projects are very limited. The infrastructure for centralized collection and processing of this potential fuel is in the initial stages of development. The preliminary estimates of waste amount will not most likely substantiate large-scale development for power production. The decision on this matter will be made at the municipal level as part of the grant program currently in development with various international agencies.

3.4.6 Conclusions

Based on the discussion above and various references reviewed, there are no substantial resources of geothermal, solar, wind energy, and solid waste that can be utilized in Armenia in the foreseeable future. Based on technical assessments, wind energy has the greatest potential for direct generation of electricity. It is also the most highly developed technology and has the greatest potential for producing significant amounts of electricity at competitive cost. While geothermal and solar are capable of significantly reducing end-use demand for electricity, only wind power is likely to make a substantial contribution to electric power generation.

References:

[1] *Power Generation and Privatization Strategy and Plan*, Draft Report, Hagler Bailly for USAID, May 2000.

[2] *Wind Energy Developments: Incentives in Selected Countries*, Energy Information Administration, 1998.

[3] *Update of Least Cost Power Investment Program*, Lahmeyer International, 1996.

[4] *Assessment of the Geothermal Resources of the Republic of Armenia*, Burns and Roe, 1998.